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Cincinnati, Ohio

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USE OF STABILIZATION PONDS IN TREATING SEWAGE AND INDUSTRIAL WASTES *

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* Presented at 8th Southern Municipal and Industrial Waste Conference, Chapel Hill, North Carolina, April 2 and 3, 1959.

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Fitzgerald and Rohlich have presented an excellent review of this subject in the October 1958 issue of Sewage and Industrial Wastes.(1) Anyone involved in the study of these facilities for the treatment of wastes should familiarize himself with the contents of this paper and the many references therein.

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The holding of sewage and other organic wastes in ponds has been practiced throughout the world for many years, in fact, even centuries, although the purposes served by so doing have varied widely. Removal of suspended matter, regulation of erratic flow patterns, storage for controlled release to water courses during high flows, fertilization of waters to enhance fish propagation, conservation of waste waters for irrigation, and biochemical stabilization of organic matter as a complete method of waste treatment, have all been used. Research is also now underway to convert the nutrients in wastes discharged to ponds into algal protoplasm which can be harvested as a source of protein.

The recognized use of stabilization ponds as a complete method for the treatment of raw sewage has been practiced in this country for just over 10 years.(2) Following the first installation in North Dakota in 1948 their use spread rapidly throughout many of the neighboring States within the Missouri Drainage Basin. By 1957 at least 136 communities serving a population of more than 125,000 were using this method of sewage treatment.(3) Communities in other sections of the country were also considering their use and some States were granting provisional approval for their construction on a more or less experimental basis. The present acceptance of this method of sewage treatment is further exemplified by the fact that from late 1956 to December 31, 1958, 254 projects have been approved for the construction of stabilization ponds in 29 States under the Construction Grants Program of Public Law 660.(4)

In addition to these it is known that ponds are in use in at least six other States.

Early in this decade the Public Health Service received requests to investigate these facilities to determine the various design criteria, their effectiveness and details of operation. Beginning in 1955 a joint State-Federal field study was initiated in the Dakotas on five ponds in those States. Also, during the summers of 1955 and 1956 the Service worked with the Texas State Department of Health to evaluate data in their files on some 190 "oxidation" ponds in that State. The results of these studies are a matter of record and will not be repeated here except to state that the studies proved that the treatment of raw sewage in stabilization ponds was practical, that properly designed and operated stabilization ponds will provide a degree of purification comparable to that obtained by conventional complete treatment processes, and that, like any other sewage treatment devices, they have advantages and disadvantages and should not be considered as a panacea for all sewage treatment needs, but they can warrant consideration in the engineering evaluation of sewage treatment needs for locations where they are applicable.(3)(5)(6)

Another purpose of these investigations was to develop our knowledge in the field to permit better definition of areas of study which should be pursued in controlled experiments for the purpose of

developing more rational design criteria and operating procedures. The construction of two such experimental facilities was undertaken, again through cooperative efforts, in the States of Missouri and Ohio. At Fayette, the Missouri State Department of Health, the Town of Fayette, and the Public Health Service entered into a cooperative arrangement which resulted in the construction of five one-acre ponds to be used by the Public Health Service in carrying out field research. A fifteen-acre pond was also constructed by the city to serve as its sewage treatment system. This pond receives the overflow from the experimental units as well as that portion of the sewage flow not required in the experiments. This installation was placed in operation about January 1, 1957. It took some three or four months to iron out various operating kinks but since April of 1957 continuous operating data have been collected at this facility by a Public Health Service-Chemist stationed at Fayette. Our first experiments were designed to obtain additional information on maximum loadings. The five ponds were operated in parallel and were loaded at 15 pound increments ranging from 15 to 75 pounds of five-day BOD per acre per day. The depth of liquid was 2.5 feet in all ponds. This method of operation was maintained for some fifteen months, terminating in May of 1958, and we are just now completing our analysis of the data. Some of the findings can be summarized, briefly, as follows:

1. During the period all ponds operated satisfactorily and without any objectional odor although ice cover occurred during

January and February of 1958 and persisted for a period of 32 days. The ponds, loaded at 15 and 30 pounds per acre per day, were not depleted of oxygen, while the three heavier loaded ponds became anaerobic some 27 days after the first ice cover. Dissolved oxygen returned in the pond receiving the 45 pound loading in about two weeks, while it took almost five weeks for the other two ponds to show substantial amounts of dissolved oxygen.

2. The BOD reductions showed relatively little variation although the higher loadings gave a slightly inferior effluent. Pond No. 1 (the 15 pound loading) showed monthly average BOD reductions ranging from a low of 83 per cent to a high of 90 per cent. Pond No. 5, the highest loading (75 pounds per acre per day) showed monthly average BOD reductions ranging from 76 per cent to 86 per cent.

3. Bacterial reductions did not vary greatly from pond to pond. Coliform organisms, as measured by the MPN, showed reductions of more than 99.5 per cent in all tests.

Since June of 1958 this facility has been operated in the following manner. Two ponds are being operated in parallel, each loaded at

approximately 45 pounds of five-day BOD per acre per day. The only difference in operating procedure is that one pond continues at a 2-1/2 feet depth while the other is 5 feet in depth. Two other ponds are being operated in series, the first receiving a loading of approximately 75 pounds of BOD per acre per day with the effluent passing into the second pond. These ponds are both operating at 2-1/2 feet depth. The fifth pond is being loaded at a rate of approximately 100 pounds of BOD per acre per day with the hope that it would fail to remain aerobic at all times, in which case it is proposed to add nitrate for odor control.

The past winter has been a severe one for this locality and ice coverage has persisted for considerable periods of time. Although all of these data have not yet been analyzed, at no time have the ponds produced any noticeable odors. It is planned to continue operations in this manner until early fall of this calendar year.

Our second experimental facility was constructed at Lebanon, Ohio, by the Ohio State Department of Correction and Welfare with the understanding that the Public Health Service would carry out experiments and tests that would be of value to that department in evaluating these facilities for possible use by them. Here we have four one-quarter acre ponds and one two-acre pond, the latter pond being designed to receive the effluent from the four smaller ones, plus domestic sewage not required for experimental use.

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Thie installation was placed in operation in July of 1958 and, because of adverse soil conditions, a considerable period of time passed before desirable liquid operating depths could be maintained. At first we were rather discouraged because of this fact but as things have worked out it has provided an opportunity to obtain information on the self-sealing characteristics of raw sewage.

Also, because of the difficulty of building up a desirable liquid depth, we were forced to divide the sewage flow into only two of the 1/4 acre ponds. This has resulted in a loading of approximately 120 pounds of BOD per acre per day for each of these ponds and it has been possible to observe conditions taking place in the initial break-in periods under adverse operating conditions.

We are also carrying out some experiments on different methods of sealing pond bottoms and dikes. In one pond we have installed a polyethylene lining. We are just now getting ready to treat two other ponds with betonite. Problems of soil permeability have posed serious questions in many locations and by taking advantage of the adverse conditions prevailing at this installation we hope to come up with some useful information relating to this subject.

It is too early to predict the results obtained at Lebanon although here also we have just gone through a very severe winter with considerable ice coverage. During extended ice coverage the ponds became anaerobic but

did not cause odors and, after the ice melt, odors were likewise absent and have remained so up to the present time. Dissolved oxygen was restored in the ponds some 14 days following the ice melt.

It is believed that, on the basis of our Dakota studies, together with our experience at Fayette and Lebanon, as well as observations of operating conditions in other climatic areas, we can make one very pertinent prediction. This is related to loadings and the probability of objectionable odors. In the Dakotas ice coverage may prevail for from five to six months. During this period the temperatures are only a degree or so above freezing and this results in a very much slowed up biological activity. With the increased temperatures following the ice break-up biological action speeds up and the winter's accumulation of fresh sludge begins to digest anaerobically at such a rate that the so-called "acid" digestion prevails with a lowering of pH and the potential production of hydrogen sulfide gases. This same condition prevails in these colder climates with many Imhoff tanks; that is, each spring the winter's accumulation of undigested sludge passes through the so-called acid cycle of digestion because there is not sufficient seeded sludge to properly buffer the reaction and maintain alkaline digestion. From personal experience in one of the Dakotas, it is recalled that it was not at all unusual to have serious gassing and foaming of Imhoff tanks accompanied by serious complaints of odors.

In those climates where the extreme low temperatures do not prevail it would be reasonable to expect that, once sludge digestion started, it would proceed in a normal way; that is, digestion under alkaline conditions. In such instances we should not expect odors any more objectionable than would be coming from the usual well-operating unheated digester even though anaerobic conditions prevailed in the sludge at the bottom of the ponds.

Under such conditions, therefore, it may well be that loadings high enough to produce anaerobiasis during certain short periods of time may result in no adverse effects. This has been borne out in our observations at three or four different locations wherein earthen basins or anaerobic cells have been receiving extremely heavy waste loads without noticeable odors. It is believed that this fact may well be of importance particularly to those concerned with treating some strong industrial wastes.

Naturally, loading and depth are the two factors that most affect the cost of these facilities and anything that can be done to reduce the area will make their application more economical. The Service has had an occasion to observe a pond installation on the West Coast which was designed according to the criteria recommended by Parker, et al, in Australia; that is, anaerobic ponds followed by aerobic ponds.(7) The observed loadings ranged from 185 pounds to 450 pounds of five-day BOD per acre per day.(8) The reductions in BOD ranged from 40 to 70 per cent with

the majority approximating 60 per cent. The aerobic pond loadings varied from 13 to 40 pounds of five-day BOD per acre per day and here the reductions varied from 50 to 85 per cent. The over-all BOD reductions at this installation ranged from 74 to 96 per cent. From these data it is apparent that, from the standpoint of work load, the anaerobic ponds do a greater amount of work. At different times it was observed that the upper layers of the anaerobic ponds were supporting an algal growth which resulted in the presence of dissolved oxygen at or near the surface while anaerobic digestion of sewage solids was taking place on the bottom. Odors have not been a problem.

One of the principal factors leading to the development of stabilization ponds was the search for a low-cost method of sewage treatment. The South Dakota Health Department recently made an evaluation of the construction costs for some 60 ponds in that State.(9) These costs were exclusive of pump stations, outfall sewers, land, and engineering fees but did include inlet piping, outlet structures, fencing, etc. The per capita costs for these installations vary from $4.27 to $37.94 with an average of $15.00. The Public Health Service also made a cost evaluation of some 71 installations in the Missouri River Drainage Basin and here the cost of the pond itself, inlet and outlet structures, and fencing ranged from $4.90 to $15.60 per capita.

The following information from the Missouri Water Pollution Board on constructions costs in Missouri is of interest.

"... In Missouri we have found that lagoons designed to serve communities of 500 to 10,000 people are constructed at an average cost of $9.84 (includes a land cost of $300 per acre) per capita, while comparable mechanical treatment plants are costing $41.58 per capita. During the past two years, 36 lagoons have been completed, and 40 are under construction or have been approved for construction. These lagoons are designed to serve a total population of 207,332."(10)

Many people have raised the questions as to the use of stabilization ponds for the treatment of industrial wastes. Here again the use of ponds or holding reservoirs for the disposal of industrial wastes is not new. Ponds or lagoons can be traced back for several decades, and it is likely that they existed prior to the time that their use was recorded in the literature. Usually, in the early use of ponds, the stabilization of the wastes was not the primary objective. They were usually used as seepage pits, settling basins, or for holding industrial wastes until greater dilution was available in the receiving streams. In 1942 Black reported on the use of lagooning of vegetable canning wastes in Illinois as early as 1913.(11) Warrick and Sanborn also made reference to some of the early work particularly in New Jersey in 1910 where cannery wastes were treated by land irrigation with lagooning of the wastes resulting from the need to store them so that they could be applied to the land in accordance with the absorption capacity of the soil.(12) Organic loadings on the basis of surface area were extremely high and anaerobic decomposition often resulted in offensive odors. Here again the most offensive odors appeared during

the early stages of decomposition and nitrate was frequently applied to supply a source of oxygen to assist in odor control. Other types of wastes, including wastes from beet sugar plants and oil refineries, also practiced the storage of wastes in artificial ponds for controlled release to streams or to seepage areas, and it was noted that this storage often resulted in BOD reductions greater than could be attributed to removal of suspended matter.

More recently, however, many persons have given consideration to the possibility of treating various types of industrial wastes in stabilization ponds wherein biochemical processes common to those prevailing in raw sewage stabilization ponds can be used to stabilize organic matter. The Public Health Service has been following this trend for the past four or five years and just recently an endeavor was made to bring together some information where it was known these facilities were being used as the primary method of waste treatment. Several industries and State Water Pollution Control agencies were most helpful in making such information available. Through this medium we have gathered available information on some 40 or 50 installations serving at least 10 different types of industries for the primary purpose of stabilizing organic wastes. A brief summary of these may be of interest.

At least seven installations are used by pulp and paper industries. Although complete design and operating data were not supplied, the available information shows the size of the plants served by such treatment

ranging from 180 to 700 tons per day. The flows varied from .65 to 8 mgd and the area of the ponds ranged from two acres to 175 acres with depths varying from 3 to 12 feet. Loadings ranged from 100 to 1,200 pounds of BOD per acre per day which gave removals ranging from 7 to 95 per cent, the 7 per cent removal being for the 1,200 pound loading. Except for this one instance, all removals reported were at least 33 per cent or more. The best known installation serving this type of industry is at Valdosta, Georgia.(13) This plant is described in the literature and the operating results are indeed remarkable.

Five installations treat packing-house or slaughter-house wastes. The size of the plant varied from a small custom killing plant with few animals per day up to a plant processing upwards of 2,500 hogs daily. The daily flows range from a thousand gallons per day to approximately three-quarter million gallons per day, and the pond areas range from 1/2 to 25 acres with depths varying from 3 to 7 feet. The loading ranged from 50 to more than 500 pounds of five-day BOD per acre per day. Two of these installations are using a combination of anaerobic and aerobic ponds and at the extreme high loadings some odors have been reported from the anaerobic unit. There is little data on the per cent of BOD removal, although one installation reports a maximum of 95 per cent. Some of these ponds follow primary settling.

There are nine reported installations treating dairy wastes either separately or in combination with domestic sewage. Very little

is reported on the size of plant being served and the amount of waste discharged. The size of pond varies from a fraction of an acre to 30 acres with depths ranging from 2 to 7 feet. Reported loadings vary from 12 to 100 pounds of BOD per acre per day and little information is given as to the efficiency of removal. One pond handling straight creamery wastes reports BOD removals of from 90 to 99 per cent. At this pond it has been necessary to add nutrient in the form of nitrate to maintain proper algal growths.

The remaining ponds treat a variety of wastes including chicken-processing wastes, wastes from various types of vegetable canneries, laundry wastes, organic chemical wastes, metal-working wastes, urea wastes, wastes from petro-chemical plants, and citrous wastes. There is very limited information on the size of plants being served; however, the pond area varies from a fraction of an acre to as much as 50 acres. Pond depths range from approximately 3 feet to as much as 12 feet. One cannery waste system is reported to have both an anaerobic and an aerobic pond and has provided BOD reductions up to 94 per cent. Some removals on chicken-processing wastes of as much as 80 per cent are reported and one petro-chemical plant reports a BOD reduction of as much as 99 per cent. The metal-working plant referred to has good operating records and reports over 99 per cent reduction in oil and suspended solids and 98 per cent reduction in BOD.(14)

Stabilization ponds totalling 32 acres are reported to be giving excellent results in treating wastes from citrous processing and vegetable canning in the lower Rio Grande valley. During the initial period of operation the ponds were receiving straight industrial waste and it was necessary to add sodium nitrate to supply essential nutrients. This was discontinued, however, when a well-stabilized effluent from the domestic sewage treatment plant was added to the raw industrial waste. Recirculation is also employed on these ponds.

In one instance, generally unsatisfactory results have been reported in an attempt to treat a mixture of domestic waste and textile mill dye waste. It was thought that the highly colored waste probably excludes light necessary to develop algae and also that the combined wastes may be unbalanced as to its nitrogen, carbon and phosphorous content.

The satisfactory results being obtained at the several stabilization ponds reported on is not unexpected. We would expect that any waste that has been demonstrated to be treatable in a conventional biological type of waste treatment process would also be amenable to treatment in a stabilization pond. Similarly, wastes that interfere with conventional biological treatment might be expected to give trouble in a pond. We would especially expect that industrial wastes requiring the addition of certain nutrients to support biological life in a conventional treatment plant would also require the addition of

those same nutrients to develop a proper biological life in the pond. This, of course, has been borne out particularly where dairy wastes and the citrous wastes have required nutrients or the addition of domestic sewage which supplies those nutrients.

It is realized that these reported cases of both successful and unsuccessful operation leave much to be desired insofar as being able to accurately design area and depth relationships into stabilization ponds for industrial wastes. We do believe, however, that the same general factors applying to raw sewage ponds are likewise applicable to industrial waste ponds. It is also believed that proper location of ponds, so that minimal odors would not give rise to complaint, may permit much higher loadings than is commonly practiced where we are trying to maintain aerobic conditions at all periods of open water under most adverse climatic conditions. As with domestic sewage ponds, we cannot compare loadings in the Dakotas and the colder climates with those in the South, just as we cannot use the same basis of design for other sewage treatment processes under all climatic conditions.

For reasons previously stated climatic conditions in the southern part of this country should favor the use of more liberal design criteria and it is firmly believed that stabilization ponds have a real place in the treatment of industrial wastes. The design should also be sufficiently flexible that advantage can be taken of the holding capacity of the ponds to serve as a buffer between some unforeseen conditions in an industry

and critical flow conditions in the receiving stream. The protection that can be afforded to the stream by interposing such a factor of safety is tremendous and is excellent insurance even following the more conventional treatment processes.

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